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Research Article

The Use of Solved Example Problems for Fostering Strategies of Self-Regulated Learning in Journal Writing

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Writing learning journals is a powerful tool to integrate self-regulated learning in classrooms. However, to exploit the full potential of journal writing, instructional support is needed that addresses the students' deficits in the use of self-regulated learning strategies. A promising means to foster learning strategies in learning journals is the provision of solved example problems along with prompts. In a quasiexperimental field study, we provided fifth-grade students ($N = 48$) with solved example problems along with prompts either right from the beginning of writing their journals or after they had already written two learning journal entries. We found that the provision of solved example problems along with prompts right from the beginning of the journal writing process fostered the quality of both cognitive and metacognitive strategies and conceptual knowledge in the initial phase. The delayed provision of solved example problems after an initial phase of journal writing yielded a detrimental effect on the quality of cognitive strategies and a beneficial effect on the quality of metacognitive strategies. In sum, our results suggest that the provision of solved example problems along with prompts right from the beginning of journal writing can effectively support fifth-grade students in overcoming deficits in the use of self-regulated learning strategies.

1. Introduction

Self-regulated learning is the ability to actively and constructively engage in a process of meaning generation in order to attain learning goals (see [1]). For instance, fifth-grade students who have just received an introductory lesson on fractional arithmetic might strive to self-regulate their understanding of the new topic by reflecting on the lesson contents at home. A key issue for effective self-regulated learning is the students' ability to apply learning strategies (e.g., [2, 3]). Specifically, according to current theoretical process models of self-regulated learning, the application of both cognitive and metacognitive learning strategies is at the heart of the *action-* or *performance-phase* in the course of self-regulated learning (e.g., [4, 5]; see also [6]). Cognitive learning strategies embrace both organisation and elaboration strategies [7]. Thus, students who strive to self-regulate their understanding of a new topic after they have left the classroom should, for instance, (a) organise the new learning contents in a meaningful way by identifying main ideas (e.g., "Today we learned the concept of fractions. A fraction describes how many equal parts an area is divided into."), and (b) elaborate on new contents by generating their own examples (e.g., "An example for the concept of fractions is when I divide my birthday cake into 12 equal pieces. In this case, each piece is 1/12 of my birthday cake."). Furthermore, the learners should engage in metacognitive learning strategies and thus try to (c) monitor their own understanding to identify comprehension problems (e.g., "I did not understand how fractions (e.g., 1/4 litre of milk) can be converted to "normal" numbers.") and, in case that they identified comprehension problems, to plan remedial activities in order to overcome the specific problems.

However, empirical findings show that the students' learning behaviour rarely conforms to this normative ideal of self-regulated learning. For instance, Rachal et al. [8] showed

that many college students hardly ever apply effective cognitive and metacognitive strategies. Given that the use of self-regulated learning strategies is strongly linked to age (e.g., [9]), fifth-grade students can be expected to show even larger deficits in applying effective strategies of self-regulated learning.

A viable means to foster strategies of self-regulated learning is writing learning journals. This activity, as conceptualised in this paper, requires students to write down their reflections on the learning contents from a previous lesson (see [10]). Specifically, journal writing can be conceived as a means to foster cognitive and metacognitive learning strategies as defined by Weinstein and Mayer [11]. When it comes to cognitive strategies, students should try to identify and structure the main contents from a previous lesson (i.e., organisation) in their learning journals. The learners therefore focus on the central contents to be learned and construct *internal* links that relate relevant aspects of a new topic to each other. Furthermore, the students should elaborate on new learning contents by generating their own examples for abstract principles and concepts or by generating possible applications of new principles in everyday life. These elaboration strategies serve the construction of *external* links that help learners to integrate new contents into their prior knowledge (see [11]). In the selecting-organising-integrating theory of active learning (e.g., [12]), organisation and elaboration (i.e., cognitive learning strategies) are essential for meaningful learning because they help learners to both build coherent mental representations of new contents and to deeply integrate these representations with their prior knowledge. Correspondingly, empirical findings in the field of journal writing show that cognitive learning strategies are crucial for beneficial effects on learning outcomes [13].

Besides fostering cognitive learning strategies, writing learning journals is further intended to elicit metacognitive learning strategies. Metacognition refers to learners' knowledge about their own cognitive processes and their ability to control and manage those processes (see [11]). In the course of journal writing, learners should engage in the metacognitive strategy of comprehension monitoring. Comprehension monitoring can help learners to detect gaps in their understanding and thus to avoid illusions of understanding (e.g., [14]). If learners detected comprehension difficulties, they can then plan courses of action intended to remedy them. Hence, the identification of specific comprehension problems should ideally be the onset for developing further cognitive learning strategies that are in service of overcoming the specific problems (see e.g., [15]). In sum, in the course of writing learning journals, students should apply cognitive and metacognitive learning strategies that are crucial for effective self-regulated learning. However, even though writing learning journals may serve as a medium for applying cognitive and metacognitive strategies of self-regulated learning, empirical studies show that simply requiring learners to write learning journals is not sufficient enough to foster the respective strategies. Specifically, empirical studies show that neither advanced high-school students [16] nor university students [13, 17] sufficiently engage in cognitive and metacognitive strategy use in their learning journals if there is no instructional support.

Against the background of research on strategy development, it can be assumed that learners' deficits in applying cognitive and metacognitive strategies in learning journals might be due to different reasons. More specifically, Flavell et al. [18] identified two different reasons for deficiencies in the use of learning strategies, namely, *production deficiencies* and *mediation deficiencies*. A production deficiency implies that learners already have the necessary cognitive skills to effectively use a strategy, but do not do so spontaneously. A mediation deficiency means that learners do not use learning strategies because they lack the necessary cognitive requirements to apply them (see also [19]). A third possible deficiency which has been identified in the development of learning strategies is the *utilisation deficiency* [20]. In contrast to production and mediation deficiencies, utilisation deficiencies do not imply that learners do not use learning strategies [20]. Rather, a utilisation deficiency is diagnosed when learners do not benefit from strategies in the initial stage of usage. One explanation for deficient utilisation is that the application of an unfamiliar learning strategy might require learners to invest large parts of their available cognitive capacity, leaving few capacities for content learning. Depending on the type of deficiency that causes the learners' strategy deficits, different instructional means of fostering learning strategies in writing learning journals should be considered (see [16]).

Prompts have been widely used as an instructional means to overcome production deficiencies in learning journals. Prompts are basically questions or hints that are designed to induce productive learning processes in order to overcome shallow processing on part of the learners (see e.g., [21, 22]). In the course of writing learning journals, prompts can be conceived as learning strategy activators [23]. Hence, prompts are designed to *activate* learning strategies but do not provide instructional guidance on how to apply the respective strategies to a high standard. For instance, prompts designed to induce cognitive learning strategies include questions such as, "In your opinion, what are the main points?" (i.e., organisation prompt, see [13]) or "Which examples can you think of that illustrate the learning contents?" (i.e., elaboration prompt; see [13]). In experiments with university students, prompts to induce cognitive and metacognitive strategies were found to foster both high-quality strategies of self-regulated learning and learning outcomes (e.g., [13, 15, 24]). However, studies with high school students revealed less promising results. Specifically, a study with advanced high school students (mean age = 17.62 years) suggests that providing learning strategy prompts is not sufficient enough to foster the use of high-quality cognitive and metacognitive strategies in the learning journals of these learners [16]. Thus, the effectiveness of prompts designed to induce cognitive and metacognitive learning strategies seems to vary between learners of different ages. Hübner et al. [16] concluded that high school students aged around 17 years, in contrast to university students, do not yet have sufficiently developed skills to apply cognitive and metacognitive strategies. More specifically, they proposed

that the lack of strategy application of high school students in prompted journal writing is mainly due to mediation deficiencies. Consequently, they argued that providing sole prompts in the course of journal writing is not sufficient for these learners. Rather, these learners would need further instructional guidance in addition to prompts which fosters the cognitive skills to apply the respective strategies in the first place.

An effective means of supporting learners in initial stages of cognitive skills acquisition is by providing worked-out examples [25, 26]. Typically, worked-out examples include the formulation of a problem, the steps taken to work out that problem, and ultimately the final solution. For the purpose of fostering the acquisition of cognitive skills used to solve algorithmic problems (e.g., problems in mathematics or physics), learning by worked-out examples has been shown to foster the acquisition of cognitive skills more effectively than learning by solving problems (e.g., [7]). Although research in the field of worked-out examples has mainly focused on algorithmic problems, there is growing evidence that example-based learning can foster the acquisition of the cognitive skills needed to solve nonalgorithmic problems as well (e.g., [16, 27, 28]). In contrast to *classical* worked examples, however, examples for nonalgorithmic problems often do not include worked-out solution steps because there are no algorithmic solutions. For example, there is no algorithm for the problem of generating a high quality response to the prompt "Which examples can you think of that illustrate the learning contents?" (i.e., for the application of a high-quality elaboration strategy). Therefore, this type of examples has been referred to as *solved example problems* (see [29]). In the course of fostering the cognitive skills needed to apply high-quality cognitive and metacognitive strategies of self-regulated learning in learning journals, a well-written learning journal example could serve as such a solved example problem.

Initial evidence for the use of learning journal examples to foster the cognitive skills to apply cognitive and metacognitive strategies was presented by Hübner et al. [16]. In a laboratory study, they provided high school students (mean age = 17.62 years) with a presentation that introduced learners to prompts in the first step and provided learners with a written learning journal example as second one. In addition, active processing of the learning journal example was elicited by requiring learners to assign passages of the learning journal to the corresponding cognitive and metacognitive prompts. They found that a solved example problem of a learning journal fostered both cognitive and metacognitive strategies in subsequent learning journals. However, in a field study with ninth-grade high school students (mean age = 14.74 years), a closely related procedure of providing both prompts and a solved example problem in an introductory presentation did not yield high-quality cognitive and metacognitive learning strategies [30]. The authors argued that providing a learning journal example in an introductory presentation might not be sufficient enough to support younger students to apply strategies of self-regulated learning in a high-quality way. Learning by worked-out examples usually implies that the worked-out examples are available until learners have gained understanding of the cognitive skill to be learned (e.g., [26, 31]). Against this background, in the present study we were interested in whether providing younger high school students (e.g., fifth-grade students aged around 11 years) with solved example problems throughout an initial phase of journal writing (e.g., their first two learning journal entries) would foster the quality of both cognitive and metacognitive learning strategies. Moreover, we addressed the open question of whether providing solved example problems throughout an initial phase of journal writing would also foster learning outcomes. Hübner et al. [16] found that although providing a learning journal example in an introductory presentation fostered the application of cognitive and metacognitive strategies in a subsequent learning journal entry, the learners did not benefit from these strategies in their initial entry. They explained this finding in terms of a utilisation deficiency (see [20]). More specifically, they argued that learners might have focused mainly on the application of cognitive and metacognitive strategies in their initial entry and thus were hardly able to devote capacity to content learning. However, as the learning journal example was withdrawn after an introductory presentation in this study, the devotion of rather large parts of the available cognitive capacity to strategy application might have partly been due to the lack of external guidance during journal writing phase. According to the *direct initial instruction principle* [32], in order to reduce cognitive load, a high level of external guidance which shows the learners exactly how to manage a task should be available throughout initial stages of learning. Therefore, it can be expected that holding solved example problems available throughout an initial phase of journal writing would yield different results. Specifically, given that the solved example problems serve as beneficial external guidance in the course of journal writing and thus decrease the cognitive capacity which has to be devoted to strategy application, it can be expected that learners have sufficient cognitive capacity left to benefit from the applied strategies.

Besides these open questions with respect to the effects of solved example problems of a learning journal in an initial phase of journal writing, it is uncertain as to whether the solved example problems could be withdrawn in a second phase of journal writing (e.g., after the first two learning journal entries) without negative effect on the quality of the students' learning strategies. In this respect, the descriptive measures reported in the study by Hübner et al. [16] suggest that—although not explicitly analysed by the authors—the learning strategy measures decreased from an initial learning journal entry to a second entry. However, this effect might also have been due in part to the short-term intervention in this study. Thus, in the present study we addressed the question as to whether the quality of learning strategies would also decrease if learners could draw on the solved example problems throughout writing their first two learning journal entries. As learners have more time to internalise the external guidance provided by the solved example problems in this case, the quality of their learning strategies might remain stable after the solved example problems have been withdrawn.

Another open issue addressed by the present study regarding the use of solved example problems of learning journals is whether it is important to provide them right from the beginning of journal writing (i.e., in an initial phase) or whether delaying the provision of solved example problems yields comparable effects. For instance, for the purpose of motivating learners by experiencing the thrill of independent success (see [33]), teachers could withhold external guidance by solved example problems in an initial phase to provide students with the opportunity to find solutions to the prompts on their own. However, providing young high school students who do not yet have the cognitive skills needed to apply cognitive and metacognitive strategies of self-regulated learning with sole prompts in an initial phase of journal writing basically resembles requiring learners to solve problems in the initial phase of cognitive skills acquisition. In this case, the students have to draw on their rather low level of internal guidance when they respond to the prompts (i.e., when they solve the problems) probably resulting in the use of learning strategies of low quality (e.g., [16, 34]). However, given that these learners do not completely fail to respond to the prompts, learners might nevertheless acquire strategies to respond to the prompts in the initial phase. Hence, it is reasonable that these learners can already draw on higher internal guidance when they receive solved example problems in a second phase of journal writing than learners who receive solved example problems right from the beginning. In this case, it can be expected that providing solved example problems designed to support learners in the initial stage of the acquisition of the skills needed to apply cognitive and metacognitive learning strategies forces learners to engage in reconciliation processes between their internal guidance (e.g., their strategy to respond to the cognitive prompts) and the external guidance provided by the solved example problems. Cognitive load theory [7, 35] provides a powerful and elaborate explanation for the consequences of such reconciliation processes. More specifically, in cognitive load theory, such reconciliation processes between internal and external guidance are referred to as sources of additional cognitive load in working memory [36, 37]. Hence, given that the capacity of working memory is limited [38], requiring learners to engage in reconciliation processes decreases the learners' resources available for the execution of beneficial learning activities (see [36]). Thus, the delayed provision of solved example problems after students have responded to the prompts on their own in an initial phase of journal writing might result in less cognitive capacity available to apply the prompted strategies to a high standard. As a consequence, these learners might not—at least in the short-term—benefit from the delayed provision of solved example problems with respect to learning strategies and learning outcomes.

2. Overview of the Study and Research Questions

The provision of solved example problems in an introductory presentation is a promising instructional support feature in addition to prompts designed to foster cognitive and metacognitive strategies of self-regulated learning in advanced high school students' learning journals [16]. However, providing a solved example problem in an introductory presentation did not yield high-quality learning strategies in younger high school students' learning journals (see [30]). As younger high school students might need more time to acquire the cognitive skills to apply cognitive and metacognitive strategies, these learners might benefit from solved example problems which are available throughout an initial phase of journal writing. However, the effects of providing solved example problems throughout an initial phase of journal writing have hardly been explored. Furthermore, it is an open question as to whether the effects of solved example problems depend on the insertion point. Specifically, to avoid load-consuming reconciliation processes between the external guidance by solved example problems and learner-generated strategies to respond to the prompts, it might be crucial that learners can draw on solved example problems right from the beginning of journal writing. Against this background, we present a quasiexperimental field study which is concerned with the effects of the immediate or delayed provision of solved example problems in addition to prompts to foster both strategies of self-regulated learning in learning journals and learning outcomes. Specifically, we addressed the following research questions

(1) Does the provision of solved example problems in addition to prompts in an initial phase of journal writing foster the quality of both cognitive and metacognitive strategies of self-regulated learning?

(2) Does the provision of solved example problems in addition to prompts in an initial phase of journal writing foster learning outcomes?

(3) Does withdrawing the solved example problems in a second phase of journal writing influence the quality of both cognitive and metacognitive strategies of self-regulated learning?

(4) Does the delayed provision of solved example problems in a second phase influence the quality of both cognitive and metacognitive strategies of self-regulated learning?

(5) Do learners who receive solved example problems in an initial phase of journal writing differ from learners who receive solved example problems in a second phase of journal writing with respect to learning outcomes at the end of the second phase?

3. Method

3.1. Sample and Design. Fifth-grade students ($N = 57$) from two German high school classrooms wrote learning journals in mathematics over the course of four lessons. Nine of the students missed at least one lesson during the study. Therefore, complete data were available for $N = 48$ students (31 females, 17 males). Their average age was 11.21 years (SD = 0.46). The average mathematics grade did not differ between the two classrooms (classroom A: 2.00, SD = 0.65;

Table 1: Prompts used in this study (translated from German).

Cognitive Prompts
Organisation
(1) "Describe and explain the main contents of the last mathematics lesson. For this purpose, you can also compose a chart that highlights the main contents."
Elaboration
(2a) "Can you create links between the contents of the last mathematics lesson and your knowledge from everyday experience?"
(2b) "How could you apply what you have learned in your spare time? Create an example." (the learners could choose to which prompt they wanted to respond to)
(3) "Create your own task with a solution that reflects the contents of the last mathematics lesson. Describe your task in a way so that a classmate could work on it. The task should be difficult. However, you should be able to solve the task."
Metacognitive prompt
Monitoring
(4) "Which part of the last mathematics lesson have you not understood yet?"

classroom B: 1.79, SD = 0.65; $t(46) = 1.09$, $P = .279$; the best grade in German schools is 1, the worst is 6). The two classrooms received parallel lessons during the study. That is, during the four lessons of the study, the two classrooms were taught the same subject matter (i.e., fractional arithmetic) in the same sequence by the same teacher.

Our field study had a quasiexperimental switching treatments design with two conditions: (a) prompts and (b) prompts plus solved example problems. Thus, our study had two phases. At the end of the first phase, the treatments were switched between the classrooms. A coin toss decided that classroom A received prompts in the first phase and prompts plus solved example problems in the second phase. Correspondingly, classroom B received prompts plus solved example problems in the first phase and sole prompts in the second phase. The students received the same prompts in both phases of the study. All students wrote two learning journal entries in each phase.

3.2. Materials. A major challenge in constructing the materials was to adequately take into account the learning prerequisites of fifth-grade high school students. In addition, as the regular teacher of the two classes had to deliver all materials, it was important to ensure a high level of teacher commitment to the materials. Therefore, we developed all materials in close cooperation with the regular mathematics teacher of the two classes.

3.2.1. Phase 1: Instructions for Writing Learning Journals. In accordance with the principles of effective strategy instruction [39], all students were shown a slide presentation in an introductory lesson which informed them about the use of writing learning journals and how it can be done. More specifically, based on a successful informed training procedure developed by Hübner et al. [16], the students were provided with background information on the utility and functional value of the cognitive and metacognitive strategies to be elicited by the prompts. For example, the functional value of linking new contents to prior knowledge (i.e., elaboration) and of identifying problems in one's own understanding (i.e., negative monitoring) was presented. Furthermore, all students were shown four prompts that they should respond to in each of their learning journal entries (see Table 1). Three of the prompts were intended to elicit cognitive learning strategies. For example, to enhance organisation the learners were provided with the prompt "Describe and explain the main contents of the last mathematics lesson." (see Figure 1). A prompt to elicit elaboration was "How could you apply what you have learned this lesson in your spare time? Create an example." The metacognitive prompt was designed to enhance negative monitoring. These prompts roughly corresponded to prompts that had been used in studies with high school students to elicit learning strategies (see [16, 30]). The learners were required to respond to each prompt in each learning journal entry. To ensure that the prompts were available during writing the learning journals, we integrated the prompts into the learners' learning journals. More specifically, the learners were provided with folders that included pre-printed pages. On each page, one prompt was used as a heading. Thus, each learning journal entry was pre-structured by four preprinted pages. Each folder consisted of eight preprinted pages (i.e., two learning journal entries) and a covering page.

Solved Example Problems. Students in the group that received prompts together with solved example problems were shown an extended version of the slide presentation in the introductory lesson. In this extended version, the presentation of each prompt was followed by a solved example problem (see Figure 2). Each solved example problem consisted of a high-quality response to the respective prompt. As it is important in learning from solved example problems that learners understand the exemplifying domain (i.e., the domain that is used to exemplify how to use the features of a good elaboration strategy, see [28]), the high-quality responses to the prompts were based on contents that the students had learned in a previous lesson (i.e., divisors, see Figure 2). The students were told that the solved example problems were taken from learning journals of fifth-grade students who are used to writing learning journals and that

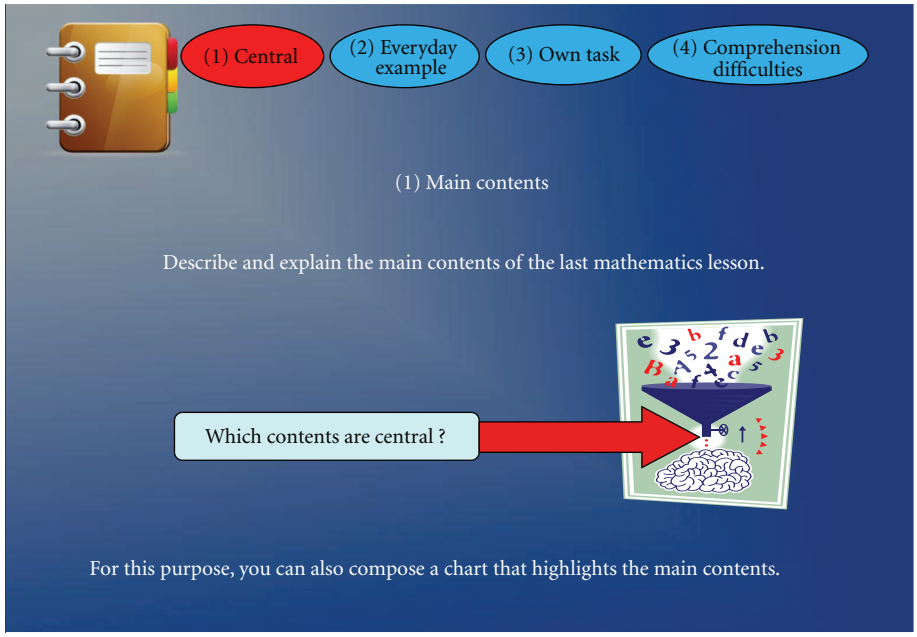

Figure 1: Screenshot of the introductory presentation: Introduction of the organisation prompt (translated from German).

the solved example problems represented good responses to the prompts. Furthermore, they were told that the solved example problems were intended to support them in responding to the prompts in their learning journals. To ensure that the solved example problems were available during writing the learning journal entries, we integrated them into the learners' learning journals. Specifically, the students were provided with the same folders as the learners without solved example problems, with the exception that the solved example problems were printed on the backs of the preprinted pages, beginning with the covering page. Hence, when learners turned the covering page, the solved example problem that corresponded to the first prompt was shown on the left side and an empty page that was headed by the first prompt was shown on the right side (see Figure 3). Thus, each learning journal entry was prestructured by four double pages.

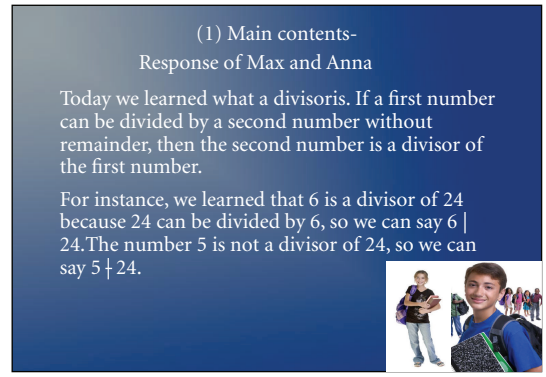

Figure 2: Screenshot of the introductory presentation: solved example problem for the organisation prompt (translated from German).

3.2.2. Phase 2: Instructions for Writing Learning Journals. The instructions that were provided in the second phase of the study (i.e., after the treatments were switched) hardly differed from the instructions that were used in the first phase. Learners from whom the solved example problems were withdrawn in the second phase were shown the same slide presentation that was shown to learners who solely received prompts in the first phase with one exception. On the first slide, the students were informed that the solved example problems were intended to support them in their initial learning journal entries. Furthermore, the students were told that—now that they had already written two learning journal entries—this support would be withdrawn and that they should try to respond to the prompts on their own. Correspondingly, students who received prompts together with solved example problems in the second phase were shown the same slide presentation that was shown to the students who received solved example problems in the first phase with one exception. On the first slide, the students were informed that they—now that they had written two learning journal entries—would receive additional support in form of solved example problems for the purpose of further improving their journal writing. Furthermore, the students were told that this would not imply that their initial learning journal entries were insufficient. The two types of folders remained the same in both phases of the study. However, the type of folders was switched between the two groups at the beginning of the second phase. All learners received new learning journal folders for their learning journal entries in the second phase.

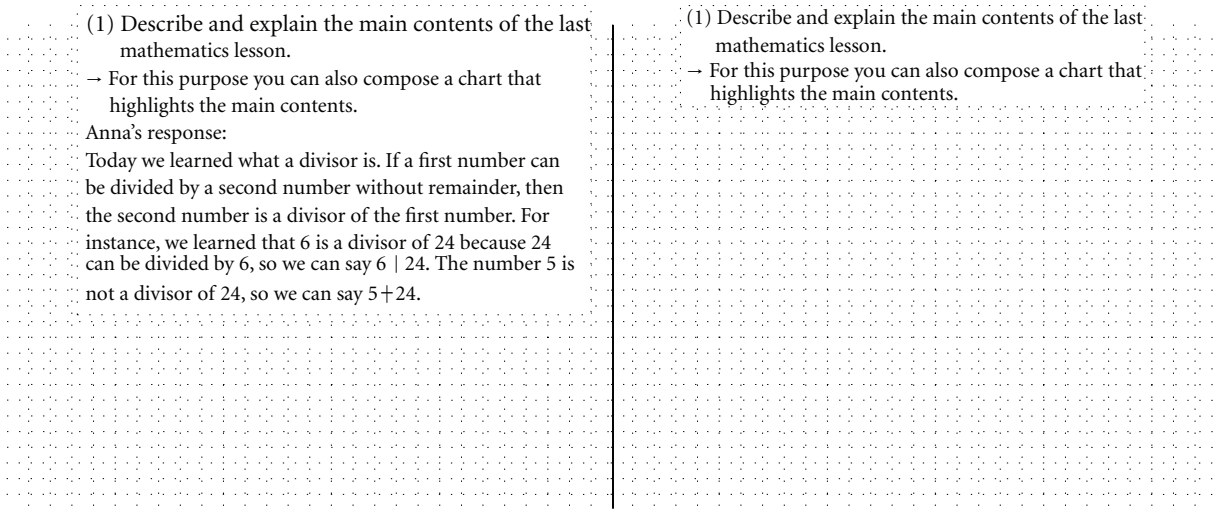

Figure 3: Preprinted learning journal pages with integrated prompt (right side) and solved example problem (left side; translated from German).

3.3. Instruments and Measures

3.3.1. Pretest: Assessment of Prior Knowledge. A pretest assessed the students' prior knowledge with respect to the topic fractional arithmetic. Specifically, the pretest consisted of five items that assessed basic knowledge of fractional arithmetic (e.g., "Henry buys five bags of potatoes. Each bag contains three-fifths kilogram. How many kilograms of potatoes has Henry bought? Illustrate your calculation."). Based on a scoring protocol, the learners' answers were scored using a 4-point rating scale ranging from 1 (*low level of understanding*) to 4 (*high level of understanding*). Two independent raters scored the written answers of 20 participants. Interrater reliability as determined by the intraclass coefficient was very good ($ICC_{2,1} = .91$). As interrater reliability was very good, just one rater scored the rest of the written answers.

3.3.2. Analysis of the Learning Journals. To assess the quality of the cognitive and metacognitive learning strategies in the learning journals, the written responses to the four prompts were analysed. For each prompt, we applied 4-point rating scales ranging from 1 (*very low quality*) to 4 (*very high quality*) to assess the quality of the respective prompted learning strategy. The rating scales were developed on the basis of the rating scales of Berthold et al. [13] and Glogger et al. ([30]; see also [34]). The responses to the organisation prompt were rated very high if the main contents of the last lesson were highlighted in a clear and structured way (e.g., "Today we learned the concept of fractions. A fraction describes how many equal parts an area is divided into. It is not limited to areas—weights or more general any quantities can be used for fractions."). The responses were rated very low if merely marginal information was presented. The responses to the elaboration prompts were rated high if the learners generated specific and detailed applications of the new contents (i.e., responses to the first elaboration prompt) and if the self-generated examples were described in whole sentences and contained a complete solution (i.e., responses to the second elaboration prompt). Short and unspecific applications (e.g., "I could use it in a furniture shop.") or short self-generated examples with a high similarity to textbook contents (e.g., "1/5 m = 20 cm") were rated as low quality elaborations. The responses to the monitoring prompt were rated high if they consisted of concrete monitoring episodes (e.g., "I did not understand how fractions (e.g., 1/4 litre of milk) can be converted to "normal" numbers."). By contrast, monitoring episodes with low concreteness (e.g., "I did not understand this topic.") were rated as low quality monitoring.

Two independent raters scored the quality of the cognitive and metacognitive learning strategies in the four learning journal entries of 20 students. The interrater reliability was very good ($ICC_{2,1} = .94$ for cognitive strategies and $ICC_{2,1} = .93$ for metacognitive strategies). As interrater reliability was very good, just one rater analysed the rest of the learning journals. For the later analyses, the scores with respect to the organisation and elaboration strategies were averaged to a total score of cognitive learning strategies. Moreover, the ratings of the learning journal entries that were written in the same phase were averaged to separate scores for the cognitive and the metacognitive strategies in the first and the second phases.

3.3.3. Posttest: Assessment of Learning Outcomes. At the end of the first phase, a posttest was used to assess the learning outcomes. The posttest was an extended version of the pretest and consisted of seven items that assessed basic knowledge of fractional arithmetic. Four items assessed procedural knowledge (e.g., "One kilogram peanuts costs €3. How much do four-fifths of a kilogram cost?"). The other three items assessed conceptual knowledge in the domain of fractional arithmetic. Conceptual knowledge refers to knowledge about facts, concepts, and principles that apply within a domain [40]. For instance, the students were required to explain

Table 2: Means and standard deviations (in parentheses) of the pretest, quality of learning strategies, and posttest scores in the two phases of the study.

	Classroom B		Classroom A	
	First phase: Prompts + solved example problems	Second phase: Prompts	First phase: Prompts	Second phase: Prompts + solved example problems
Prior knowledge				
Pretest	2.63 (0.59)		2.88 (0.55)	
Quality of learning strategies				
Cognitive strategies	3.12 (0.55)	2.57 (0.49)	2.76 (0.61)	2.52 (0.50)
Metacognitive strategies	2.06 (0.98)	1.85 (0.66)	1.35 (0.47)	1.60 (0.70)
Learning outcomes				
Procedural knowledge	2.76 (0.67)	2.88 (0.62)	2.92 (0.54)	3.15 (0.62)
Conceptual knowledge	2.98 (0.60)	3.02 (0.42)	2.87 (0.53)	2.77 (0.50)

the basic principles of fractional arithmetic or what the number 2/3 means. At the end of the second phase, learners received a second posttest. This posttest consisted of the same items as the first posttest with the exception that all cover stories and numbers were varied (e.g., "One kilogram strawberries costs €4. How much do five-eights of a kilogram cost?"). Based on a scoring protocol, the learners' answers were scored using a 4-point rating scale ranging from 1 (*low level of understanding*) to 4 (*high level of understanding*). Two independent raters scored the written answers of 20 participants. Interrater reliability as determined by the intraclass coefficient was very good ($ICC_{2,1} = .98$ for the first posttest and $ICC_{2,1} = .95$ for the second posttest). For the later analyses, the scores of each posttest were averaged to separate scores for the procedural knowledge and the conceptual knowledge in the first and the second phase.

3.4. Procedure. Both strategy instruction and the data collection took place in the students' familiar classroom environment and were conducted by the regular mathematics teacher of the two classrooms during regular mathematics lessons. Thus, the data of classroom A and classroom B were collected separately. To ensure that both the introductory presentations and the materials were properly delivered, the teacher was trained by one of the researchers two days before the presentations and materials were needed. In addition, to address potential open questions or uncertainties, there was a daily exchange between the teacher and one researcher throughout the entire study.

In a first lesson, all students took the pretest. In the next lesson, all students filled in a questionnaire on demographic data. Then the teacher delivered the respective version of the introductory presentation. After the presentation, the students were provided with their learning journal folders. In the next two lessons, the teacher gave parallel lessons on fractional arithmetic in both classrooms. Journal writing was assigned as homework for each lesson. In the following lesson, all students worked on the first posttest. Furthermore, the teacher collected all learning journal folders. Thereby, the first phase of the study ended.

In the next lesson, the second phase of the study began. In this lesson, the teacher delivered the respective versions of the slightly modified introductory presentation to the students. After the presentation, all students were handed new learning journal folders. In the next two lessons, the teacher gave parallel lessons on fractional arithmetic in both classrooms. Journal writing was assigned as homework for both lessons. In the following lesson, all students worked on the second posttest. Furthermore, the teacher collected all learning journal folders, thereby ending the second phase of the study. In the following lesson, all students were informed about the purpose of the study. Moreover, they received—without any prior notice—a personalised participation certificate and a lanyard keychain for their participation.

4. Results

Table 2 presents the means and standard deviations for the two quasiexperimental groups on prior knowledge, learning strategy measures (quality of cognitive and metacognitive strategies), and learning outcomes in the two phases of the study. An alpha-level of .05 was used for all statistical analyses. As effect size measure, we used d qualifying values of approximately 0.20 as small effects, values of approximately 0.50 as medium effects, and values of approximately 0.80 or bigger as large effects (cf. [41]).

With respect to prior knowledge, a t-test revealed no significant difference, $t(46) = 1.50$, $P = .138$. Hence, there was no a priori difference between the two quasiexperimental groups with respect to this important learning prerequisite. Nevertheless, we included prior knowledge as a covariate in subsequent analyses with respect to learning outcomes in order to reduce error variance.

4.1. Effects in the Initial Phase of Journal Writing

4.1.1. Effects on Learning Strategies. With respect to research question 1, we were interested whether the provision of solved example problems in addition to prompts in the initial phase of journal writing would foster the quality of

both cognitive and metacognitive strategies of self-regulated learning. Regarding the quality of cognitive strategies, a t-test yielded a significant and medium difference in favour of the solved-example-problems group, $t(46) = 2.13$, $P = .019$, $d = 0.63$ (one-sided t-test). The learners who received prompts together with solved example problems in the initial phase applied cognitive strategies of higher quality in their learning journals than learners who solely received prompts. Regarding the quality of metacognitive strategies, a t-test revealed a significant and strong effect in favour of the solved-example-problems group, $t(33.30) = 3.18$, $P = .001$, $d = 0.94$ (t-test for unequal variances; one-sided). Thus, the provision of solved example problems in addition to prompts in the initial phase of journal writing also fostered the quality of metacognitive learning strategies.

4.1.2. Effects on Learning Outcomes. Regarding research question 2, we were interested whether the provision of solved example problems in addition to prompts in the initial phase of journal writing would foster learning outcomes. With respect to procedural knowledge, a t-test did not yield a significant effect in favour of the solved-example-problems group, $t(45) = 0.63$, $P = .265$ (one-sided t-test). Hence, learners who received prompts together with solved example problems in the first phase did not outperform learners who merely received prompts with respect to the acquisition of procedural knowledge. However, with respect to conceptual knowledge, a t-test yielded a significant and medium effect in favour of the solved-example-problems group, $t(45) = 1.70$, $P = .048$, $d = 0.51$ (one-sided t-test). Thus, learners who received prompts together with solved example problems acquired more conceptual knowledge in the initial phase than learners who solely received prompts.

4.2. Effects in the Second Phase of Journal Writing

4.2.1. Effects on Learning Strategies. With respect to research question 3, we were interested whether withdrawing the solved example problems in the second phase of journal writing would influence the quality of the cognitive and metacognitive strategies in the learning journals. For the quality of cognitive strategies, a t-test revealed a significant and strong decrease in the second phase of journal writing, $t(23) = 4.73$, $P < .001$, $d = 1.08$ (dependent t-test). Thus, learners from whom the solved example problems in the second phase of instruction were withdrawn showed a strong decrease in the quality of cognitive strategies in their learning journals in the second phase. Regarding the quality of metacognitive strategies, a t-test yielded no significant effect, $t(23) = 1.13$, $P = .266$ (dependent t-test). Withdrawing the solved example problems did not influence the quality of metacognitive strategies in the learning journals that were written in the second phase.

With respect to research question 4, we analysed whether the delayed provision of solved example problems as additional guidance to prompts would influence the quality of cognitive and metacognitive strategies in the learning journals. For the quality of cognitive strategies, we found a significant and small decrease from the first to the second phase of journal writing, $t(23) = 2.64$, $P = .015$, $d = 0.44$ (dependent t-test). Hence, the delayed provision of solved example problems as additional guidance to prompts in the second phase yielded cognitive strategies of lower quality as compared to providing sole prompts in the first phase. For the quality of metacognitive strategies, however, a t-test revealed a significant and small increase in the second phase of journal writing, $t(23) = 2.22$, $P = .037$, $d = 0.42$ (dependent t-test). Hence, the delayed provision of solved example problems as additional guidance to the prompts in the second phase fostered the quality of metacognitive strategies in the learning journals that were written in the second phase.

4.2.2. Effects on Learning Outcomes. With respect to research question 5, we were interested whether learners from whom the solved example problems were withdrawn and learners who received solved example problems delayed would differ with respect to learning outcomes at the end of the second phase. With respect to procedural knowledge, a t-test did not yield a significant effect, $t(45) = 0.75$, $P = .457$. Thus, the two quasiexperimental groups did not differ with respect to procedural knowledge at the end of the second phase. Regarding conceptual knowledge, however, we found a different pattern of results. A t-test revealed a significant and medium effect in favour of the group that had the solved example problems withdrawn in the second phase, $t(45) = 2.31$, $P = .012$, $d = 0.69$. Hence, the group that received the solved example problems in the second phase did not catch up with the group that received solved example problems in the initial phase with respect to conceptual knowledge at the end of the second phase. In order to explore whether the pattern of results regarding the conceptual knowledge scores had changed from the end of the initial phase to the end of the second phase, we furthermore contrasted the conceptual knowledge scores after the initial phase and the second phase within the two conditions. Neither in the group that had the solved example problems withdrawn in the second phase of journal writing nor in the group that received delayed solved example problems, we found significant differences between the conceptual knowledge scores after the initial phase and after the second phase, $t(22) = 1.54$, $P = .138$, and $t(22) = 1.74$, $P = .095$, respectively. Thus, the pattern of results had hardly changed from the end of the initial phase to the end of the second phase.

5. Discussion

In summary, our study made two contributions to the problem of fostering cognitive and metacognitive strategies of self-regulated learning in learning journals of high school students by providing solved example problems along with prompts. (a) Providing fifth-grade students with solved example problems along with prompts fostered both cognitive and metacognitive strategies of self-regulated learning and the acquisition of conceptual knowledge in the initial phase of journal writing. (b) The delayed provision of solved example problems along with prompts in the second phase of journal writing fostered metacognitive strategies but was

detrimental with respect to the quality of cognitive learning strategies and did not foster learning outcomes.

The result that providing fifth-grade students with solved example problems in addition to prompts fostered the quality of both cognitive and metacognitive learning strategies in the initial phase of journal writing complements previous findings regarding the use of providing learning journal examples along with prompts to enhance strategies of self-regulated learning in learning journals of high school students (see [16, 30]) in two ways. On the one hand, our study shows that the combination of both prompts and solved example problems can—in principle—not only foster learning strategies of advanced high school students (i.e., eleventh-grade students; see [16]) but can also foster learning strategies of younger high schoolers, such as fifth-grade students. This suggests that both younger and advanced high school students do not only have production deficiencies that can be overcome by sole prompts but also have mediation deficiencies. That is, the students lack the cognitive skills necessary to apply cognitive and metacognitive strategies of self-regulated learning to a high standard. Hence, to foster the respective strategies in high school students' learning journals, instructional support should address both production and mediation deficiencies in the initial phase of journal writing. In this respect, our results suggest that the combination of prompts and solved example problems is a powerful instructional approach to overcome these deficiencies in the initial phases of strategy application. On the other hand, against the background of Glogger et al.'s [30] finding that providing ninth-grade students with a learning journal example in an introductory presentation did not yield high-quality strategies of self-regulated learning our results suggest that keeping the solved example problems available throughout the initial phase of journal writing was crucial for the beneficial effects in our study. Specifically, by integrating the solved example problems into the learners' learning journal folders, we provided learners with the opportunity to draw on the external guidance provided by the solved example problems during their first responses to the prompts (i.e., during the entire initial phase). Therefore, learners were provided with more instructional guidance than by providing a learning journal example in an introductory presentation. Research on learning from *traditional* worked-out examples shows that worked-out examples should be available until learners have gained understanding of the to-be-learned skill (e.g., [25]). Keeping in line with this, our result that the learners who received solved example problems in the initial phase of journal writing achieved—at least with respect to the quality of cognitive learning strategies—high scores in the initial phase (see Table 2) suggests that providing learners with solved example problems throughout the initial phase of journal writing has an added value as compared to providing learners with a learning journal example in an introductory presentation.

Besides these promising effects of providing solved example problems with respect to fostering the quality of cognitive and metacognitive strategies of self-regulated learning in learning journals, our study furthermore shows that providing learners with solved examples problems along with prompts also fostered learning outcomes in the initial phase. Specifically, we found that learners in the solved-example-group outperformed their counterparts in the group with sole prompts with respect to the acquisition of conceptual knowledge in the initial phase. This result stands in contrast to the previous finding that high school students did not benefit from their strategies with respect to learning outcomes in an initial phase of journal writing due to utilisation deficiencies (see [16]). One explanation for this contradistinction is that in our study the students could draw on the solved example problems throughout the entire initial phase whereas the solved example problem was withdrawn after an initial presentation in the study by Hübner et al. [16]. Hence, in the present study, the solved example problems might have provided learners with more instructional guidance during the application of learning strategies in their learning journals. As a consequence, the learners in our study might have been required to invest relatively less cognitive capacity in the application of the cognitive and metacognitive strategies, leaving more capacity for content learning (see [32]). From this view, the finding that providing learners with prompts and solved example problems in the initial phase of journal writing did not foster procedural knowledge seems surprising at first glance. An explanation for the beneficial effect of the provision of solved example problems along with prompts on conceptual knowledge and the neutral effect on procedural knowledge might be that especially the cognitive prompts (see Table 1) elicited learning strategies that were focused on conceptual aspects of fractional arithmetic. For instance, in response to the organisation prompt, learners predominantly highlighted new concepts or principles and hardly procedural aspects, such as the execution of an algorithm. Furthermore, in response to the elaboration prompts, learners mainly generated examples that showed how they could use a new principle in everyday life (e.g., that they could calculate how many birthday cakes they would get if each of their ten guests brought three-fourths of a birthday cake) without elaborating on the different calculation steps. Consequently, as the learners who received solved example problems in the initial phase applied these strategies to a higher standard, they acquired more conceptual knowledge in the initial phase than learners who solely received prompts. However, as learners hardly focused on procedural aspects of fractional arithmetic in their prompts responses, learners in the solved-example-group did not outperform their counterparts in the group that solely received prompts with respect to the acquisition of procedural knowledge even though they applied cognitive and metacognitive strategies to a higher standard. Note that—to our knowledge—none of previous studies in the field of fostering cognitive and metacognitive strategies of self-regulated learning in learning journals (e.g., [10, 13, 24, 42]) reported separate scores for conceptual knowledge and procedural knowledge. Therefore, it is an open question as to whether the cognitive and metacognitive prompts generally tend to focus learners on conceptual aspects of the learning contents or whether the results are specific for this study.

One important restriction of our findings with respect to the initial phase of journal writing is that we did not employ a condition in which a class did not receive any instructional support in the initial phase. Hence, we do not know whether the instructional means had an added value as compared to no instructional support regarding the quality of cognitive and metacognitive learning strategies. However, in the light of previous findings which show that even university students struggle with the application of high quality learning strategies in their learning journals when no instructional support is provided (e.g., [13, 17]), it is reasonable to assume that at least the combination of prompts and solved example problems fostered the quality of strategies of self-regulated learning as compared to no instructional support in the initial phase. Another restriction of our findings regarding the initial phase follows from the fact that there was no condition which solely received solved example problems in the initial phase of journal writing. Consequently, we do not know whether the combination of prompts and solved example problems in the initial phase of journal writing has an added value as compared to sole solved example problems. However, as the solved example problems included the prompts (see Section 3), it would have hardly been possible to isolate the effects of prompts and solved example problems in the present study. Nevertheless, it remains an open question as to whether the provision of solved example problems and thus integrated prompts would have fostered the quality of cognitive and metacognitive learning strategies in the students' learning journals to a similar extent as the combination of separate prompts and solved example problems.

In contrast to our promising results regarding the provision of solved example problems along with prompts in an initial phase of journal writing on both strategies of self-regulated learning and the acquisition of conceptual knowledge, we found that withdrawing the solved example problems after the first two learning journal entries yielded a substantial decrease in the quality of cognitive learning strategies. Moreover, in line with the finding that high quality cognitive learning strategies are especially crucial for high learning outcomes [13], we found that learners from whom the solved example problems were withdrawn did not further improve with respect to conceptual knowledge from the end of the initial phase to the end of the second phase of journal writing. Regarding the quality of metacognitive strategies, we did not find a significant decrease in the second phase of journal writing. However, the students did not show the use of high-quality metacognitive strategies in either the initial phase in which the students could draw on the solved example problems or the second phase. The rather low quality cognitive and metacognitive strategies found in the second phase suggest that the students did not internalise the external guidance provided by the solved example problems to a sufficient degree in the initial phase of journal writing and thus did not adequately acquire the skill to consistently apply the cognitive and metacognitive learning strategies to a high level of quality. One reason for this inadequate internalisation might be that we did not require learners to self-explain the solved example problems. Specifically, a central guideline for fostering learning from worked-out examples is that self-explanation activities on part of the learners should be elicited because the students' self-explanations are crucial for the intended knowledge-building activities in example-based learning (see e.g., [14, 26, 43]). Thus, prompting the learners to actively process the solved example problems in the initial phase of journal writing might have yielded better results in the second phase. However, requiring learners to self-explain the solved example problems might have also overwhelmed the fifth-grade students. For instance, it has been shown that requiring learners to engage in self-explanation activities imposes additional cognitive load on the learners (e.g., [44, 45]). Hence, eliciting self-explanations might have also yielded a cognitive overload on part of the fifth-grade students resulting in detrimental effects.

Besides this open question with respect to a potential added value of fostering self-explanation activities in the initial phase, it is also an open issue how an adaptive fading of the solved example problems in writing learning journals could be integrated in the instructional setup used in our study. Recent research in the field of learning from worked-out examples suggests that instructional guidance should be faded in a manner adaptive to the learners' individual understanding of the cognitive skill to be learned (e.g., [31, 46]). Regarding the setup used in the present study, this would mean that the external guidance by the solved example problems should be faded to the extent that the learners acquire the skills to apply the cognitive and metacognitive strategies to a high standard. More specifically, such an adapted fading procedure could be established by using journal writing as a means to assess the students' learning strategies in a first step (see [47]) and by adding or withdrawing solved example problems of learning journals in a second step. Furthermore, in addition to the external guidance by the solved example problems, teachers could provide the students with individual feedback that would help them to further improve the quality of their learning strategies and thus to take the next step in self-regulated learning (see [34]). However, up to now the question is open as to whether an adaptive fading of solved example problems and the provision of feedback would yield high-quality strategies of self-regulated learning in the long-term.

Our second contribution to the problem of fostering cognitive and metacognitive strategies of self-regulated learning in learning journals of high school students by providing solved example problems along with prompts refers to the effects of the delayed provision of solved example problems. We found that the delayed provision of solved example problems in the second phase of journal writing was detrimental with respect to the quality of cognitive learning strategies. One explanation for this finding could be that the instructional guidance provided by the solved example problems did not adequately relate to the knowledge base of these learners. More specifically, as students who solely received prompts in the initial phase, nevertheless found ways to respond to the cognitive prompts and thus applied cognitive strategies of considerable quality (see Table 2), it can be expected that providing solved example problems in

the second phase required learners to engage in reconciliation processes between their internal guidance that they had developed in the initial phase (i.e., their strategy to respond to the cognitive prompts) and the external guidance provided by the solved example problems. Hence, in terms of cognitive load theory [7, 35], the delayed provision of solved example problems might have increased cognitive load and thus decreased the cognitive capacity available to apply cognitive strategies to a high standard. The students, therefore, were hindered by the delayed provision of solved example problems with respect to the application of cognitive strategies of self-regulated learning. In addition, the requirement to reconcile internal and external guidance might have drawn on the students' motivational resources for responding to the cognitive prompts (see [48]). Our result that the students who were provided with delayed solved example problems did not catch up with learners who received the solved example problems in the initial phase with respect to the acquisition of conceptual knowledge even though these learners did not further improve from the end of the initial phase to the end of the second phase could also be a consequence of the reconciliation processes between internal and external guidance. More specifically, given that high quality cognitive learning strategies are especially crucial for high learning outcomes [13], the absent catch-up effect could be due to the relatively low quality of cognitive learning strategies in the second phase. The finding that the delayed provision of solved example problems nevertheless fostered the quality of metacognitive learning strategies supports our interpretation from the perspective of cognitive load theory. The learners who received solved example problems at a later time showed the use of very low quality metacognitive strategies in the initial phase of journal writing (see Table 2). Hence, it is reasonable that the learners acquired hardly any strategies to respond to the metacognitive prompt in the initial phase. Consequently, the external guidance provided by the solved example problems might have hardly interfered with the students' internal guidance and thus served as beneficial scaffolding to increase the quality of the metacognitive strategies in the learning journals. Besides that, it has to be acknowledged that, in sum, all learners showed the use of rather low quality metacognitive strategies in both phases of the study. A reasonable explanation for this could be that even the combination of solved example problems and prompts did not provide sufficient instructional guidance with regard to the application of high-quality metacognitive strategies. This finding is in line with previous studies which indicate that it may be generally more difficult for learners to apply metacognitive strategies to a high standard than to apply high-quality cognitive strategies (e.g., [24, 34]). The application of metacognitive strategies is possibly a learning activity that students tend to minimise naturally because they do not find it very rewarding to question their own understanding [24]. In the present study, this might have been even aggravated by the fact that the learners were merely prompted to monitor their understanding but were not prompted to plan and apply remedial activities in order to overcome potential comprehension difficulties. Hence, as the learners were not prompted to use the detected comprehension difficulties as the onset for the planning and the application of remedial activities, they might have perceived questioning their understanding as a waste of time and effort in the present study. Thus, in line with the finding that prompting metacognitive strategies in learning journals is particularly beneficial when they result in remedial activities [15], it can be expected that prompting both monitoring and planning of remedial strategies would have yielded better results.

Note that one important restriction of our findings with respect to the delayed provision of solved example problems is that we do not know whether the detrimental effect on the quality of cognitive learning strategies applies only in the short-term or in the long-term as well. For instance, it is reasonable that the reconciliation processes between internal and external guidance diminish over time because the learners get used to drawing on the external guidance provided by the solved example problems. Thus, the delayed provision of solved example problems might have delayed effects on the quality of cognitive strategies of self-regulated learning. Furthermore, we do not know whether learners perceived responding to the prompts on their own as being motivating in the initial phase of journal writing and whether the delayed provision of solved example problems affected the learners' motivation in the second phase of journal writing. Therefore, further research is needed that addresses both the short- and the long-term effects of the delayed provision of solved example problems to foster cognitive and metacognitive strategies in learning journals and which explicitly assesses cognitive load and the learners' motivation during journal writing.

In addition, it is an open question as to whether the learners who received sole prompts in the initial phase would have been better off without the solved example problems in the second phase. The design of the present study required that learners in both conditions received parallel lessons throughout the study. One disadvantage of this field study design was that there was only a restricted number of fifth-grade classes available who could run parallel during our study. Therefore, it was not possible to employ conditions which received either type of instructional support (i.e., prompts or prompts and solved example problems) in both phases. As a result, our study does not allow for between-subjects comparisons regarding the effects of the instructional means in the second phase of journal writing (e.g., whether sole prompts or prompts plus solved example problems yield better effects in a second phase when learners received sole prompts in the initial phase). In future studies it would be interesting to compare all four sequences of either prompts or the combination of prompts and solved example problems with respect to their potential to foster cognitive and metacognitive strategies of self-regulated learning in learning journals.

Besides the aforementioned restrictions and the several open questions for further research, our findings imply the following conclusions with respect to integrating self-regulated learning at school. First, when teachers intend to engage fifth-grade students in writing learning journals as follow-up course work as a means to integrate self-regulated learning in their classrooms, the teachers should not only

provide cognitive and metacognitive prompts but also solve example problems right from the beginning. Evidently, providing both prompts and solved example problems of a learning journal in an initial phase of journal writing can effectively foster the quality of both cognitive and metacognitive strategies of self-regulated learning as well as the acquisition of conceptual knowledge. In the light of the finding that students tend to benefit more if researchers conduct the strategy instruction instead of their regular teachers [49], the results of the present study suggest that prompts and solved example problems can form a powerful combination in service of supporting fifth-grade students in both applying and benefiting from cognitive and metacognitive strategies of self-regulated learning in learning journals. For the concrete integration of these instructional means in classrooms, the learning journal folders with integrated prompts and solved example problems that were used in the present study can be seen as a promising starting point. Moreover, our results suggest that the teachers should not withdraw the solved example problems before the learners have successfully internalised the external guidance provided by the solved example problems. From this view, both prompts that require learners to actively explain the solved example problems to themselves and a formative assessment of the students' expertise on learning strategies might serve as promising add-ons to the instructional setup used in the present study.

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